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Western Ecological Research Center

Sierra Nevada Global Change Research Program

Sierra Nevada Forest Dynamics: Pattern, Pace, and Mechanisms of Change

Annual Report for Fiscal Year 1999

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EXECUTIVE SUMMARY

The Sierra Nevada Global Change Research Program began in 1991 as a peer-reviewed, competitively-funded component of the National Park Service's (now USGS-BRD's) Global Change Research Program. While Sequoia, Kings Canyon, and Yosemite national parks form the core study areas of the program, the full study region encompasses adjacent public lands.

The goal of the Sierra Nevada Global Change Research Program is to understand and predict the effects of global changes on montane forests. By far the greatest limitation to understanding and predicting the effects of future global changes is the lack of a precise mechanistic understanding of how contemporary forest structure and function are controlled by the physical environment, disturbances, and biotic processes. Our research program therefore places landscape patterns within the context of the physical template (abiotic factors such as climate and soils), disturbances (such as fire), and biotic processes (demography, dispersal, growth, and competition). Our program focusses on developing a mechanistic understanding of this simple model as it applies to Sierra Nevada forests in particular, but also for the montane forests of western North America in general.

Our program consists of integrated studies organized around three themes: paleoecology, contemporary ecology, and modeling. The *paleoecological theme* takes advantage of the Sierra Nevada's rich endowment of tree-ring and palynological resources to develop an understanding of past climatic changes and the consequent responses of fire regimes and forests. The *contemporary ecology theme* takes advantage of the Sierra Nevada's substantive climatic gradients as "natural experiments," allowing us to evaluate climatic mechanisms controlling forest composition, structure, and dynamics. The *modeling theme* integrates findings from the paleoecological and contemporary studies, and is the indispensable vehicle for scaling up our mechanistic findings to regional landscapes, and predicting which parts of montane landscapes may be most sensitive to future environmental changes.

The Sierra Nevada Global Change Research Program currently focusses on addressing nine central sets of questions:

- What is the relative importance of topography and soil on site water balance in the Sierra Nevada, and how well does this compare with model predictions?
- What is the role and importance of reproduction in determining forest pattern and forest sensitivity to climatic change? By what mechanisms does climate control reproduction, and therefore forest sensitivity to climatic change?
- How do seed dispersal, seedling dynamics, and fine-scale variations in topography and soils interact with climatic change to affect forest sensitivity and change at local scales?
- How does climatic change affect the spatial extent, landscape pattern, and severity of fires?

- What are the relative importances of tree recruitment, death, and growth rates, and their interannual variabilities, in determining forest response to climatic variation in space and time?
- What portions of Sierra Nevada landscapes are most sensitive to climatic changes (temperature, precipitation, and seasonality), what are the implications of this for a greenhouse world, and what are the implications for land managers?
- Does climate synchronize fire regimes at subcontinental scales? If so, what large-scale climatic phenomena drive the synchrony?
- Can agents of pattern formation and mechanisms of forest change be generalized at subcontinental scales?
- How do the relative importances of agents of pattern formation vary among different climates? Is our understanding of mechanisms of forest change sufficient for a single model to explain forest dynamics at several different sites across the continent?

In 1999, substantial progress was made in addressing each of these questions. For example, within our established long-term forest dynamics plots arrayed along a climatic (elevational) gradient, 47 new 25×25 m seedling dynamics quadrats were established, in which the fates of tens of thousands of tree seedlings will be followed annually for at least the next four years. Fire-scar chronology networks were compared among the southwestern U.S., the Sierra Nevada, the Blue Mountains in Oregon, and the Cascades in Washington, revealing climatically-driven periods of asynchrony among fire regimes of the Pacific Southwest and Pacific Northwest. In a paper accepted in *Ecological Applications*, computer simulations were used to determine which portions of the southern Sierra Nevada landscape are most sensitive to climatic change, and how this knowledge can be applied by managers to design monitoring programs. Additionally, the Sierra Nevada global change staff worked with the other USGS-BRD global change programs within the Western Mountain Initiative (Olympic, Glacier, and Colorado Rockies) to map out a series of collaborations meant to draw broad generalizations about the effects of global changes on mountain ecosystems.

In 1999 we published, or had accepted for publication, twenty-eight scientific manuscripts (including one Ph.D. dissertation) related to the Sierra Nevada Global Change Research Program. A comparable number of talks and poster presentations were given at universities, professional meetings, and agency workshops.

The Sierra Nevada Global Change Research Program initiated new partnerships and continued old ones. After ten years of collaboration, our principal investigators at Duke University, Montana State University, and the University of Arizona continue to be an integral and indispensable part of our team. Additionally, principal investigators worked toward common goals with scientists from the University of California, University of Washington, Oregon State University, U.S. Forest Service, and the National Park Service. Our staff also focussed on outreach and technical assistance. We were interviewed by newspapers and television crews; gave presentations to governmental, university, and school groups; and provided extensive technical assistance to the National Park Service, such as by developing goals for fire management programs, assisting in preparation of fire and natural resources management plans, training park staff, and designing monitoring programs.

Besides continuing research, data analysis, and manuscript preparation that addresses the nine central questions listed above, fiscal year 2000 will see a major push toward drafting a book that integrates and synthesizes results to date of the Sierra Nevada Global Change Research Program.

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